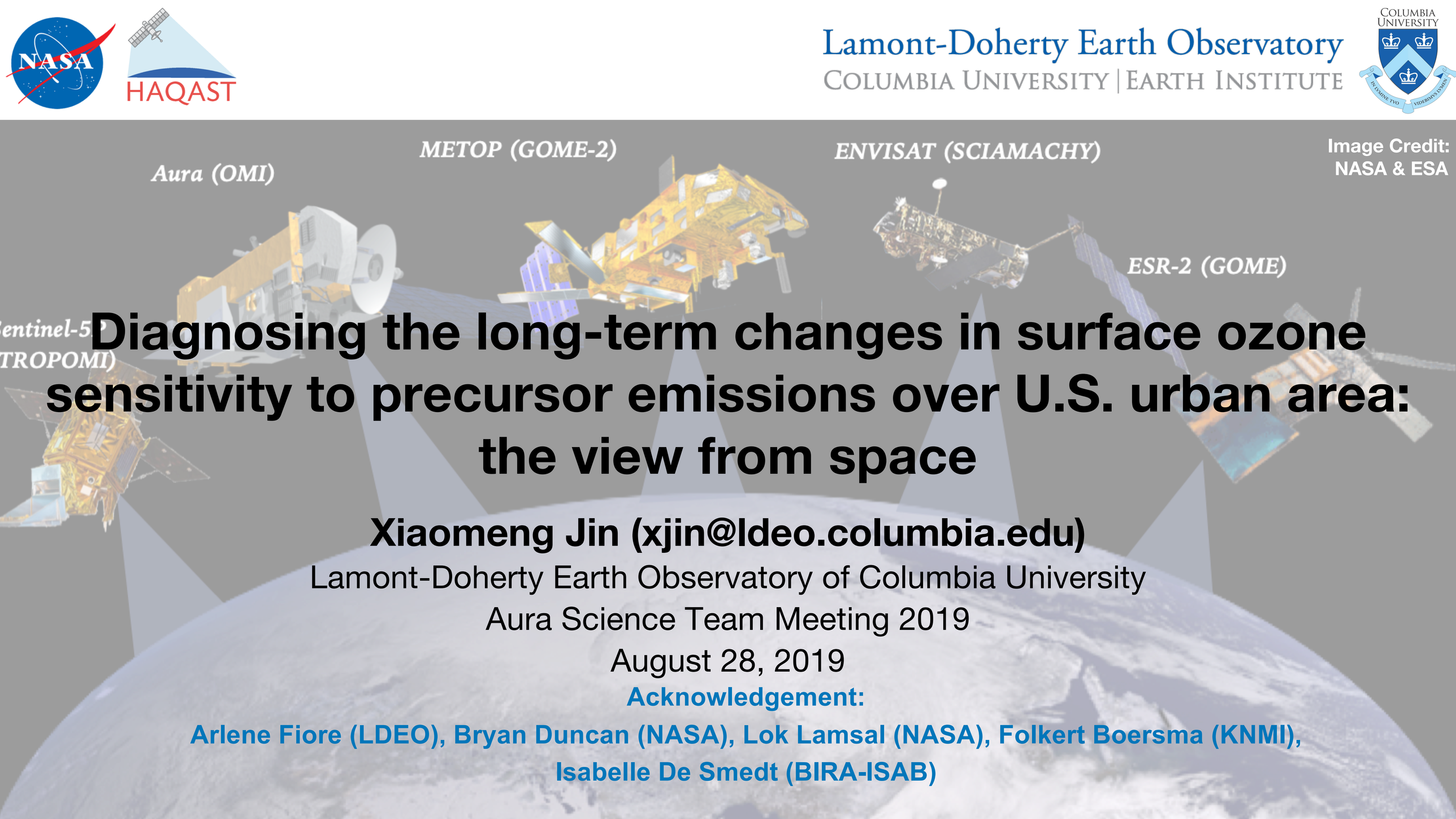

Image Credit: NASA & ESA

Diagnosing the long-term changes in surface ozone sensitivity to precursor emissions over U.S. urban area: the view from space

Xiaomeng Jin (xjin@ldeo.columbia.edu)

Lamont-Doherty Earth Observatory of Columbia University

Aura Science Team Meeting 2019

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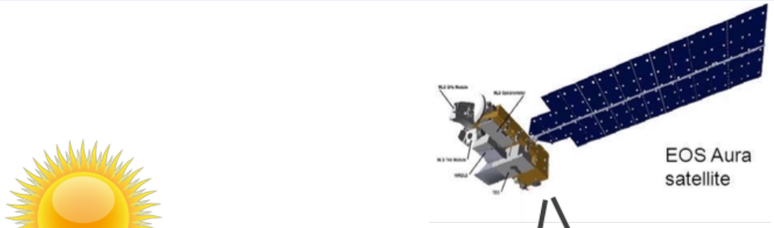
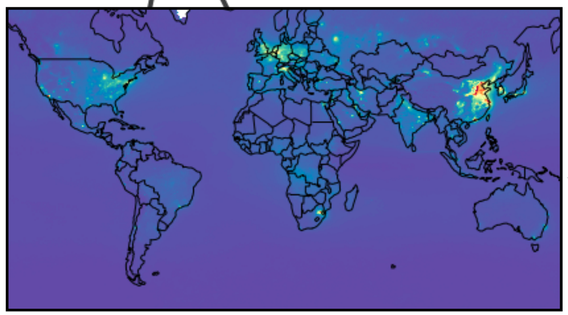
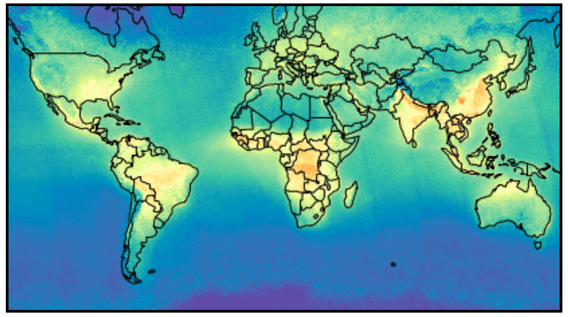
Using satellite observations of NO_2 and HCHO to diagnose O_3-NO_x-VOC chemistry





NO_2 Tropospheric Column



HCHO (Formaldehyde) Column

Surface Ozone (O_3)

Satellite HCHO/NO_2

high

NO_x↓ O_3↓
VOC↓ O_3 ×
(NO_x-Limited)

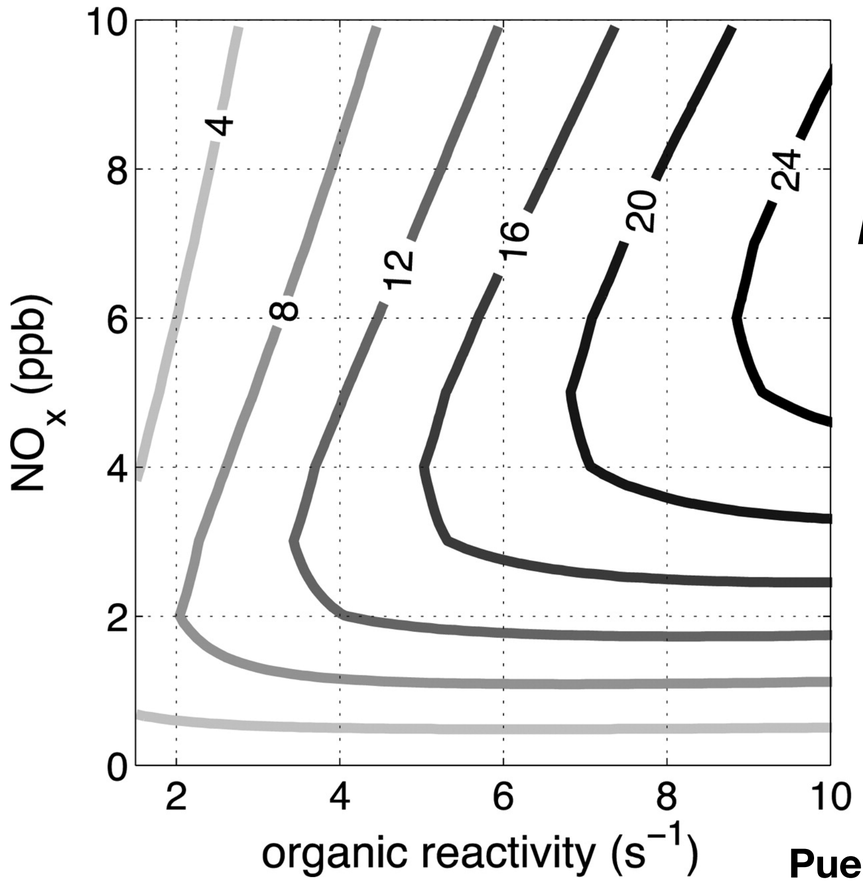
low

VOC ↓ O_3 ↓
NO_x ↓ O_3 ↑
(VOC-Limited)
or NO_x-saturated

Martin et al., 2004
Duncan et al., 2010
Jin et al., 2017

Connecting satellite-based HCHO/NO_2 with O_3 exceedance (> 70 ppbv) probability

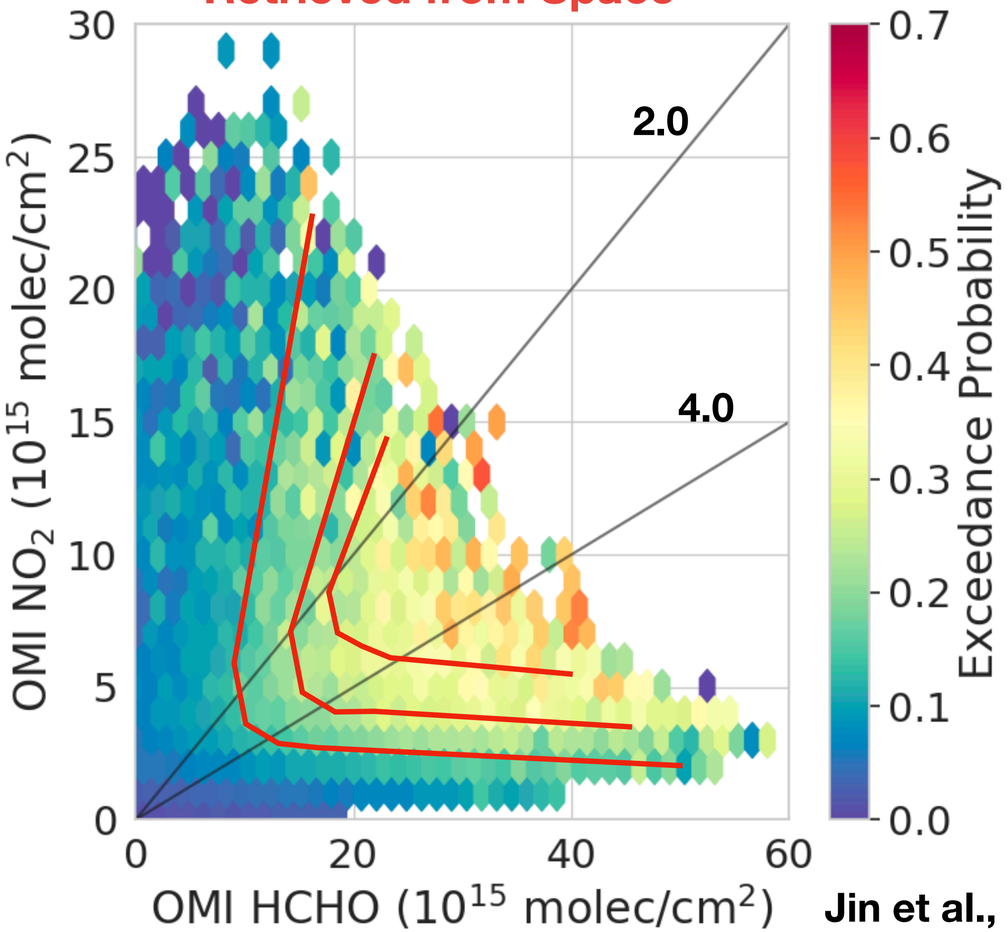
Derived from Analytical Model



***P*O3 (ppb h^{-1})**

Puesede et al., 2015

Retrieved from Space

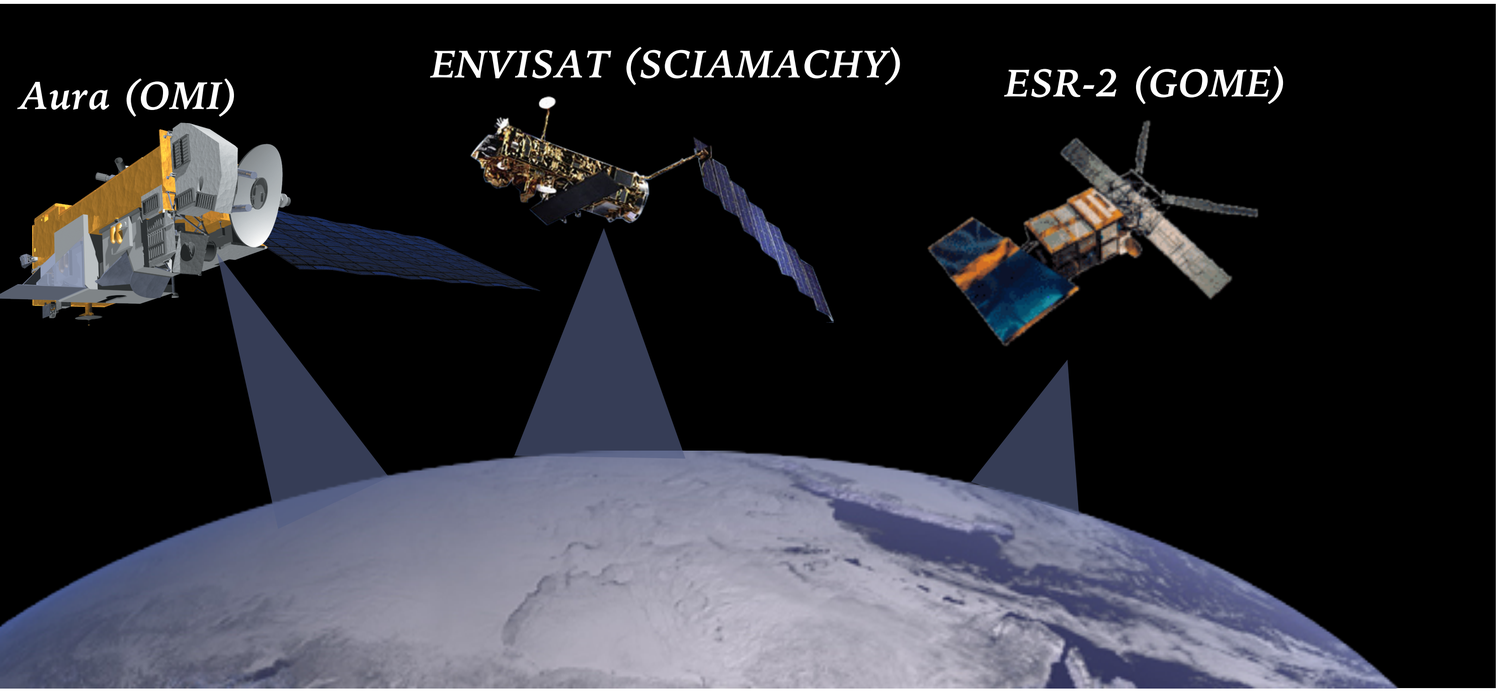


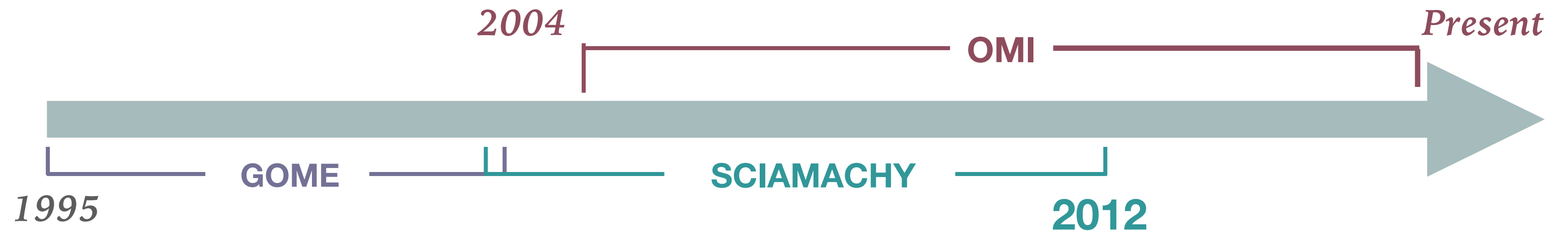
Jin et al., in prep

- OMI HCHO/NO_2 < 2.0: O_3 exceedance is **more** likely to occur with NO_x reduction (NO_x-saturated).
- OMI HCHO/NO_2 > 4.0: O_3 exceedance is **less** likely to occur with NO_x reduction (NO_x-limited).
- Between 2.0 ~ 4.0: O_3 production regime is uncertain.

Ground-based O_3: EPA AQS network
OMI NO_2 and HCHO: gridded QA4ECV daily products

Analyzing the evolution of surface O_3 sensitivity using harmonized multi-satellite HCHO/NO_2

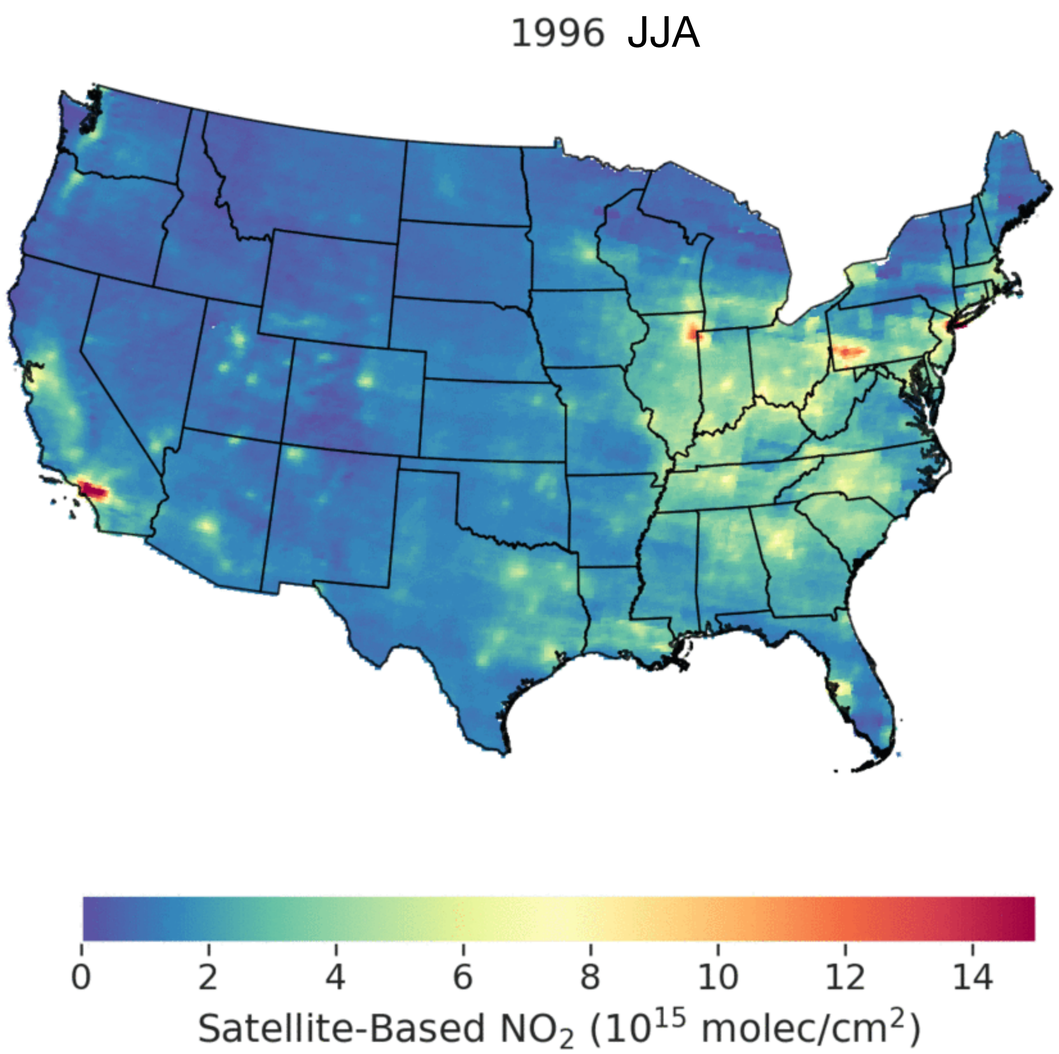




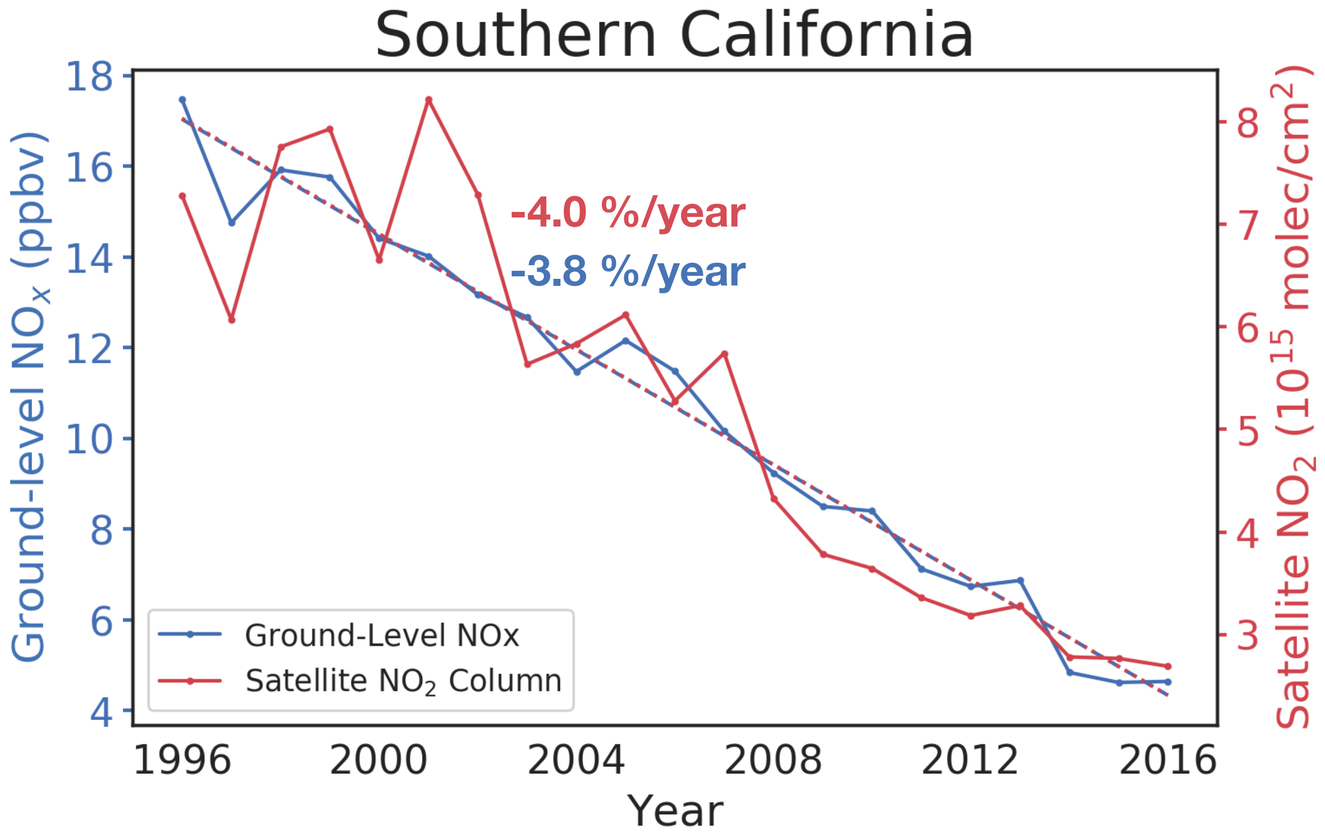
Harmonization of monthly multi-satellite HCHO and NO_2:

1. Consistent retrieval algorithm (QA4ECV).
2. HCHO and NO_2: Adjust the overpass time difference by calculating the difference between SCIAMACHY and OMI during overlap period at a coarse resolution.
3. NO_2: Correct resolution difference by applying a resolution correction factor derived from OMI (Geddes et al., 2017), but allow the correction factor to vary with time.

Large decline in NO_2 observed from satellite and ground-based observations



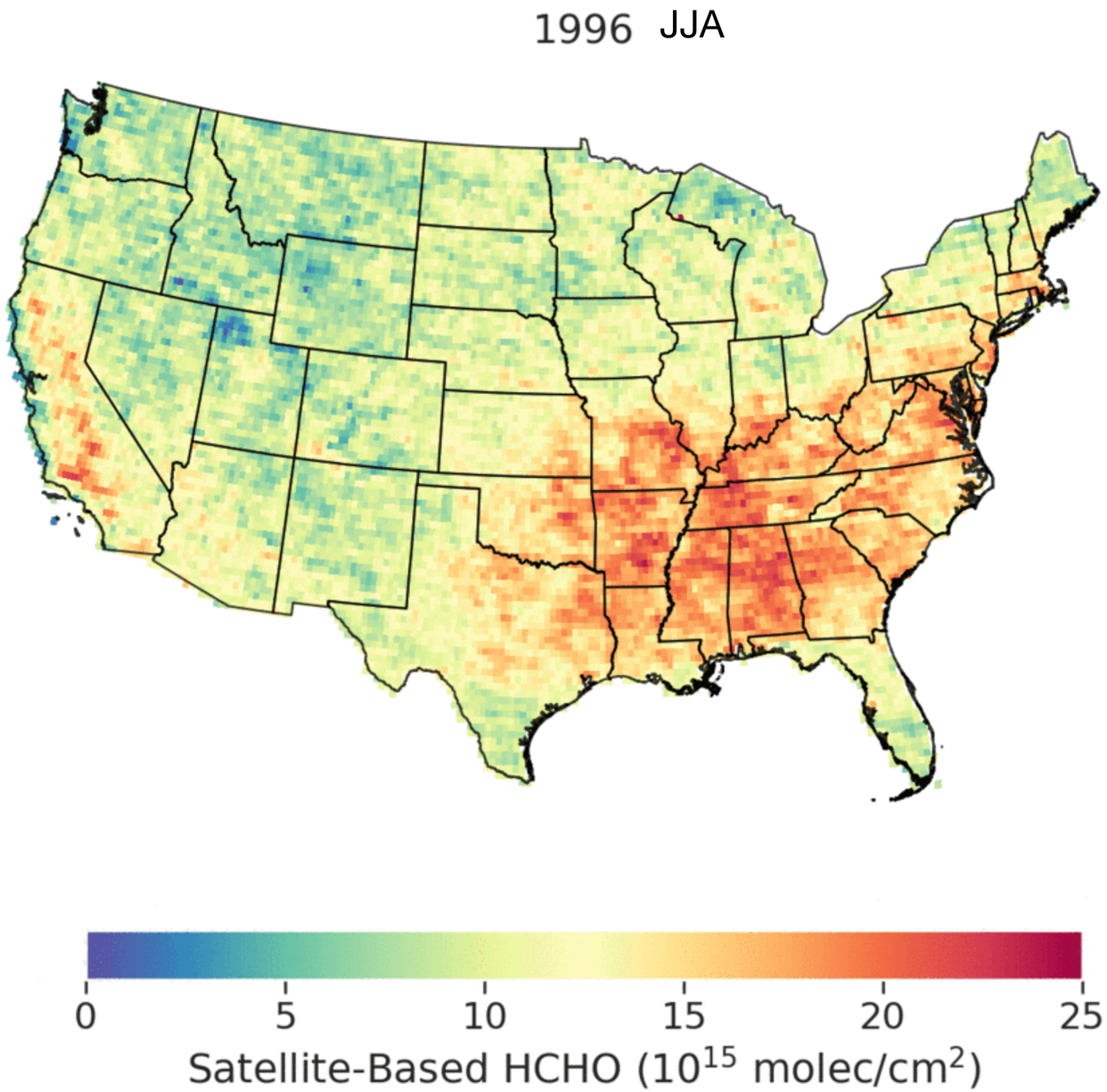
Summertime mean satellite-based NO_2 vs. ground-based surface NO_x



Jin et al., in prep

Ground-based NOx: EPA AQS network, hourly data sampled at OMI overpass time

Satellite retrieved summertime mean HCHO from 1996 to 2016

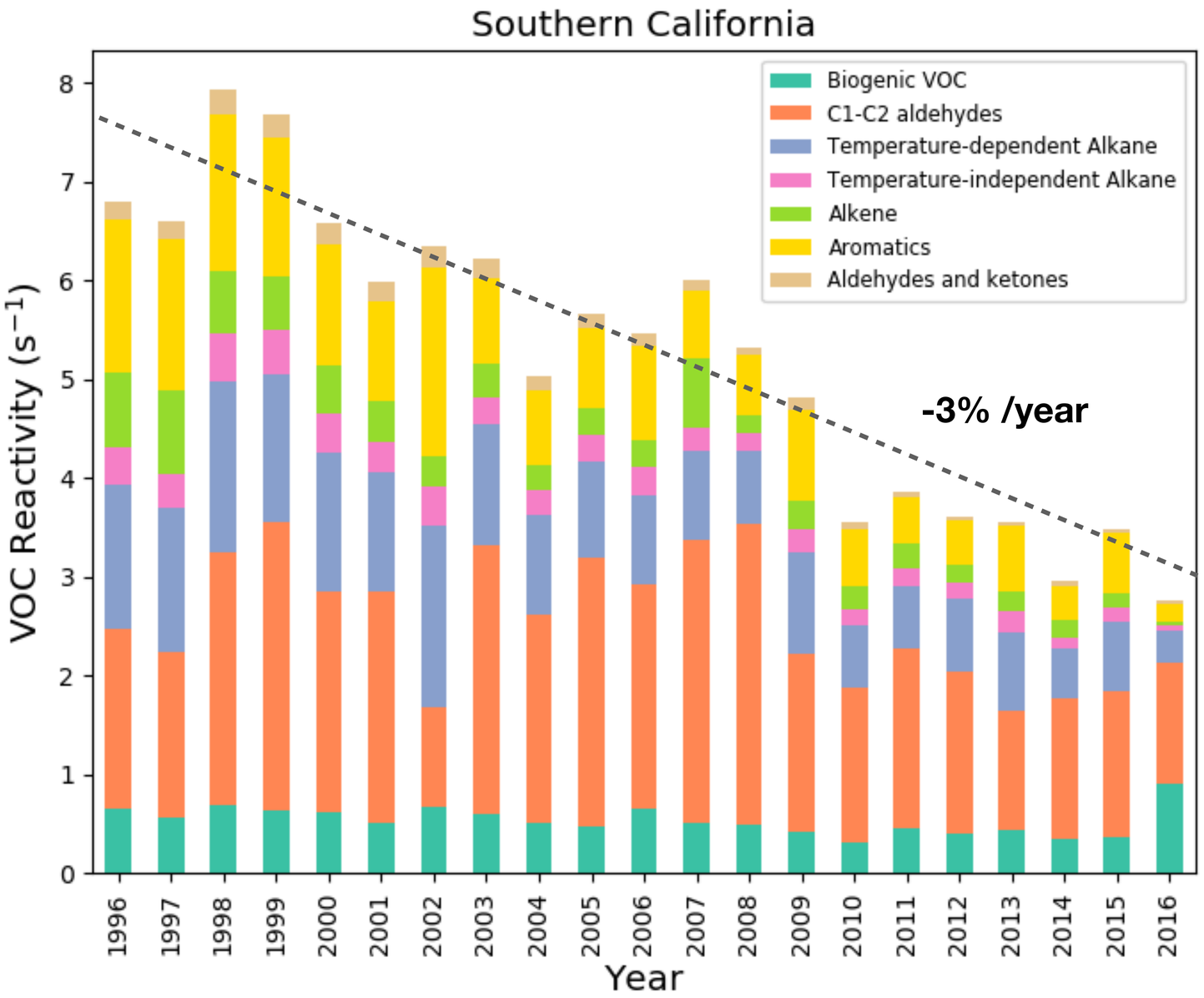


Jin et al., in prep

Ground-based observations suggest decreasing trends of reactivity-weighed VOCs over urban areas

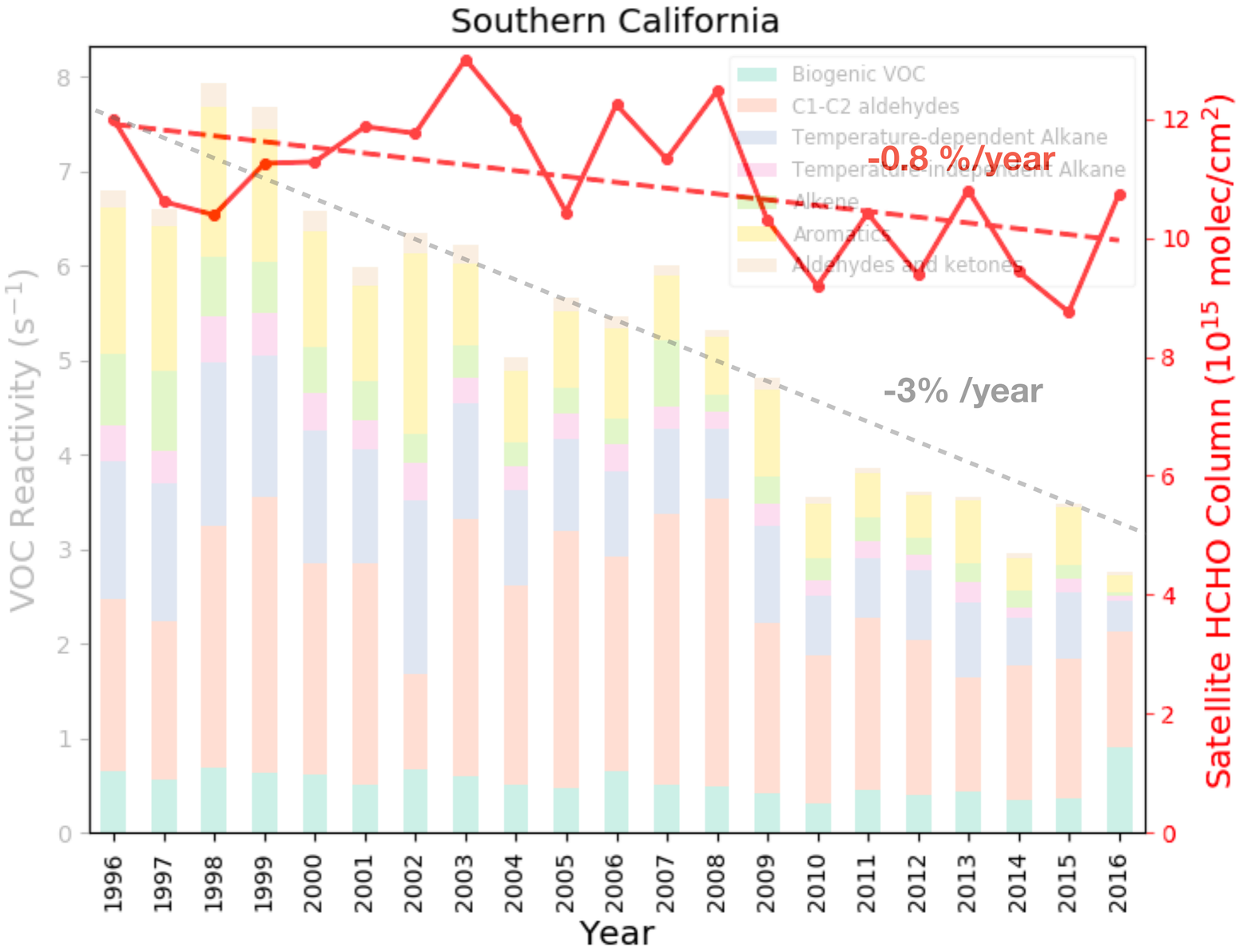
VOC Reactivity: Sum of measured VOCs weighted by reaction rate with OH.

~ Daily VOC measurements collected from PAMS sites.



Jin et al., in prep

Space-based HCHO underestimate the decreasing trends of reactivity-weighed VOCs

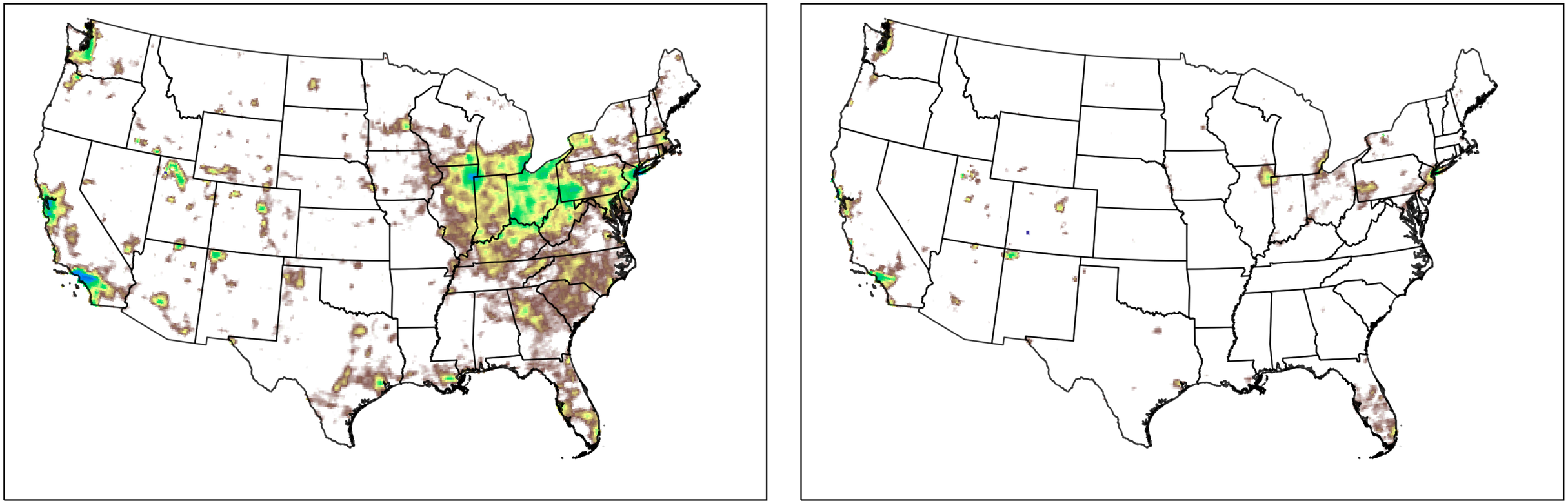


Jin et al., in prep

Satellites show shrinking areal extent of NO_x-saturated O_3 production chemistry as NO_x emissions decline

1996 - 2000 (Summer)

2013 - 2016 (Summer)

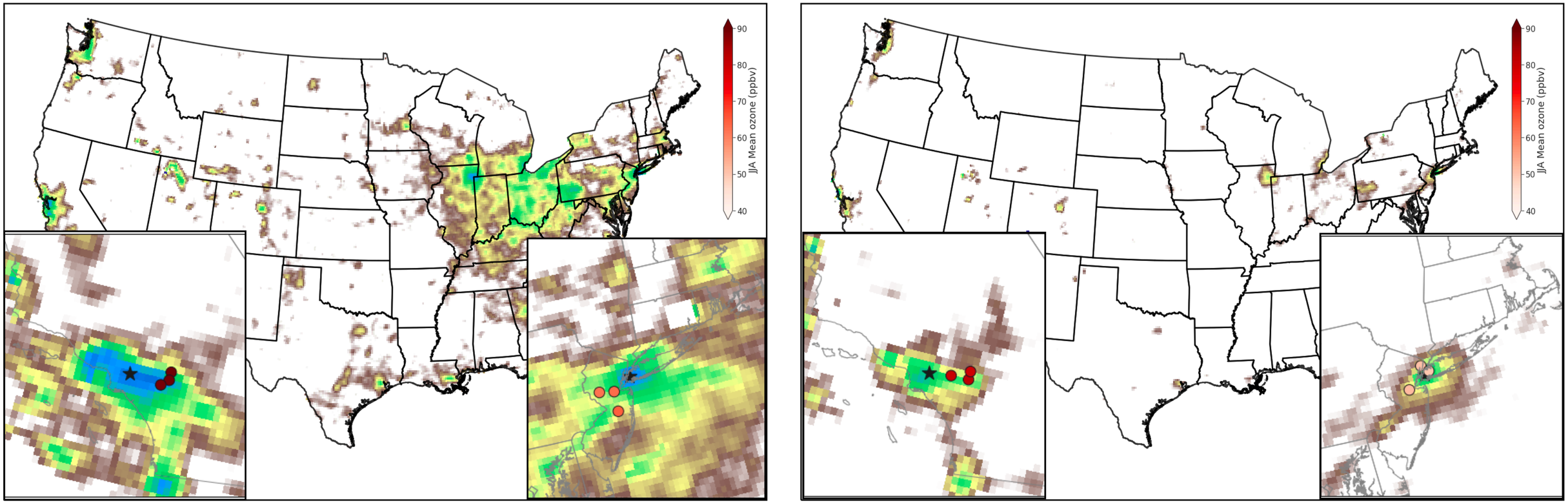


Jin et al., in prep

Peak ozone moving towards city center

1996 - 2000 (Summer)

2013 - 2016 (Summer)



VOC-Limited (NO_x-saturated)

NO_x-Limited

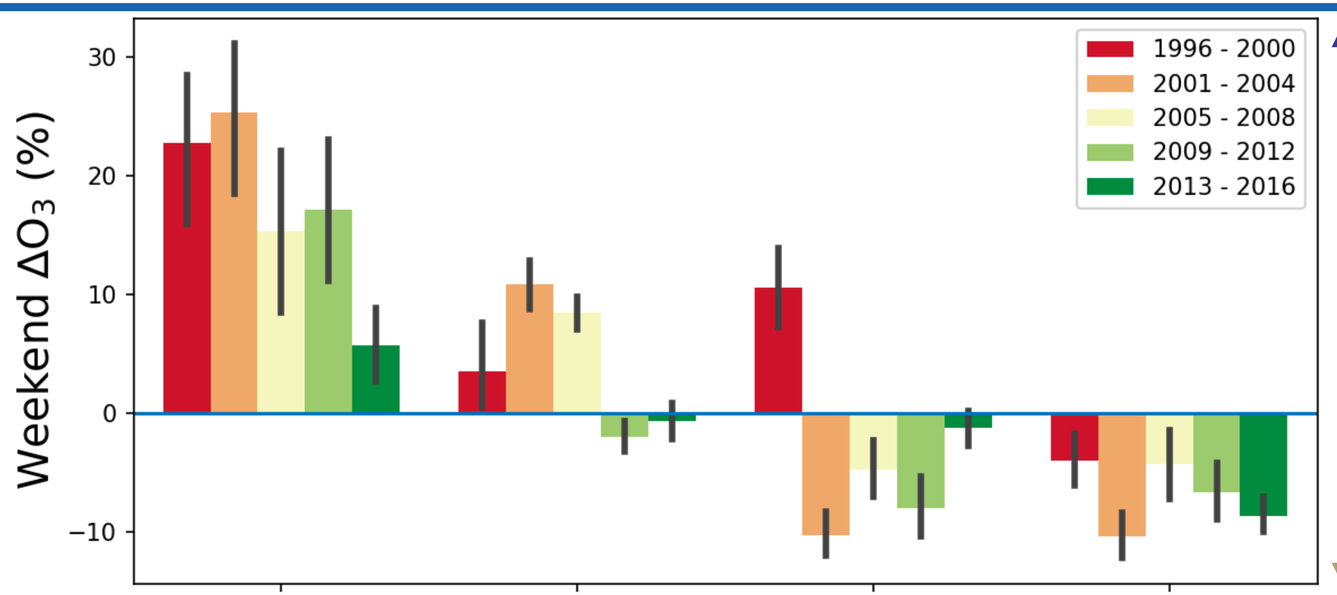
0 1 2 3 4 5 6

Multi-satellite $HCHO/NO_2$

Jin et al., in prep

Reversal of O_3 weekend effect as a result of O_3 production regime transition

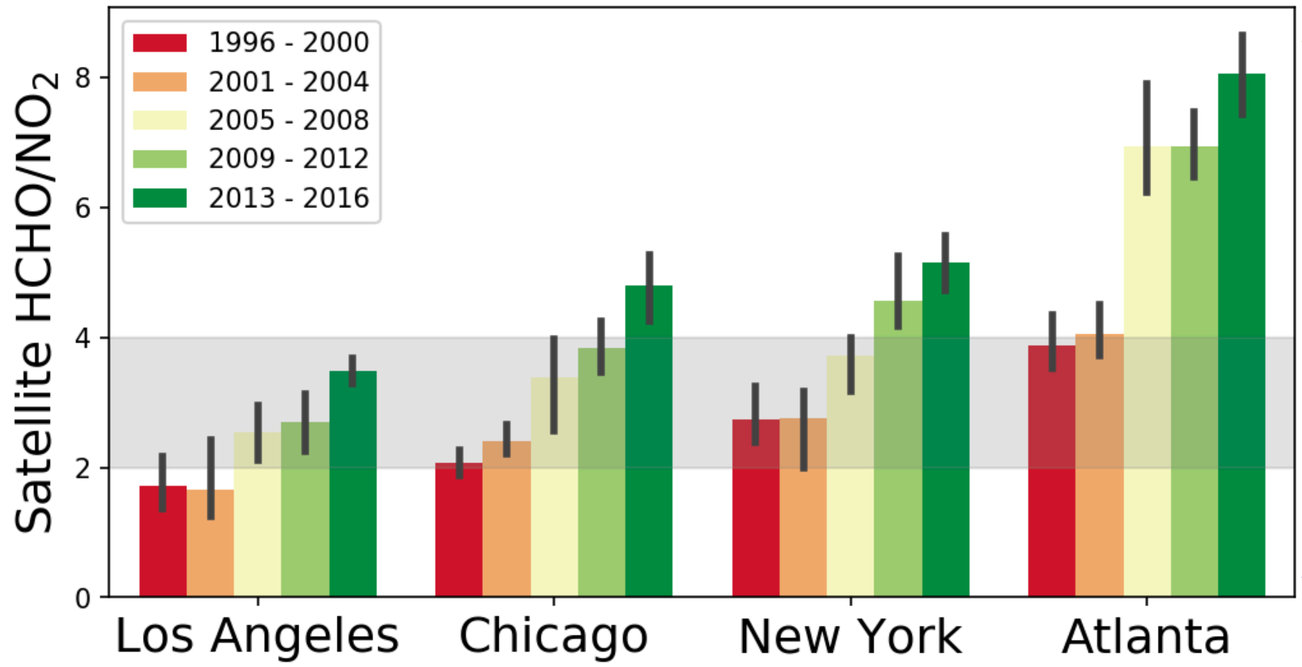
Ground-based O_3 Observations (Summer) Weekend O_3 - Weekday O_3



NO_x-saturated (VOC-limited)

NO_x-limited

Space-based $HCHO/NO_2$ (Summer)



NO_x-limited

Regime Transition

NO_x-saturated (VOC-limited)

Jin et al., in prep

Summary

- Satellite-observed HCHO/NO_2 can diagnose the non-linear O_3-NO_x-VOC chemistry, but subject to uncertainties.
- Two-decade multi-satellite observations show large changes of O_3 production regimes over U.S. urban areas.
- The new generation TROPOMI data have promising value to detect the short-term variability of O_3 chemistry.